CLAIMS

1. A method of microwave pre treatment of a multi-phase material prior to a subsequent operation on the material, the material having a first phase of material and a second phase of material, the method comprising heating the material with microwaves, producing a power density of at least $10^9 Wm^{-3}$ in a continuous process in which the material moves into and through a microwave treatment area and experiences exposure to microwaves, in the treatment area for a time of the order of ½ second or less, for a short enough time to avoid causing substantial chemical changes to one, or both of the phases of the multi-phase material, and passing the material out of the treatment area for said subsequent operation.

2. A method according to claim 1 wherein said material experiences microwaves in said treatment area for a time of the order of (i) 0.1 second or less; (ii) 0.01 second or less; or (iii) 0.001 second or less.

3. A method according to claim 1 or claim 2 wherein pulses of microwaves, are emitted substantially continuously and the pulses have a duration of the order of (i) 1μs or less; or (ii) 10μs or less; or (iii) 100μs or less; (iv) 1ms or less; (v) 10ms or less; 100ms or less.

4. A method according to claim 3 wherein the substance, whilst in the treatment area, experiences a series of pulses of energy, said series having a number of pulses of the order of: (i) 100 pulses or more; (ii) 50 pulses or more; (iii) 10 pulses or more; (iv) 5 pulses or more; (v) 2 pulses or more; (vi) one pulse.

5. A method according to any preceding claim wherein the power density produced by the microwaves in the treatment area is of the order of (i) $10^{15} Wm^{-3}$ or more; or (ii) $10^{16} Wm^{-3}$ or more.

6. A method according to any preceding claim wherein the bulk temperature of the material is raised by less than 200°C, and preferably less than 150°C.

7. A method according to claim 6 wherein the bulk temperature of the material is raised by of the order of, or less than: (i) 50°C; (ii) 20°C; (iii) 10°C.

8. A method according to any preceding claim wherein said material flows through said treatment area at a rate of at least 100 tonnes an hour.

9. A method according to claim 8 wherein said material flows through said treatment area at a rate of the order of 1000 tonnes an hour or more.

10. A method according to any preceding claim wherein the first phase comprises a desired mineral and the second phase a rock substrate surrounding the mineral, and wherein the microwave energy significantly weakens the bond strength between the mineral and the surrounding substrate by causing local differential thermal expansion.

11. A method according to claim 10 wherein the energy is applied to the material for a short enough time to avoid causing substantial chemical changes to (i) the mineral; and/or (ii) both the material and substrate, that would detrimentally influence the efficiency of subsequent separation of the mineral and substrate.

12. A method according to any one of claims 1 to 10 wherein the first phase comprises a mineral and the second phase comprises water, and wherein said pre-treatment comprises dehydration, said electromagnetic energy drying said mineral.

13. A method according to claim 12 wherein the microwaves also cause directly or indirectly fracturing or weakening of the mineral.

14. A method according to claim 12 or claim 13 wherein said first phase comprises (i) coal; or (ii) other hydrated mineral.

15. A method of separating a mineral from an ore comprising pre-treating the ore in accordance with any one of claims 1 to 11 and subsequently comminuting the ore, preferably by grinding or milling, or crushing.

16. A method according to any preceding claim wherein the power density within the treatment area produced by the microwaves is from the group: of the order of 10^{10} Wm^{-3}, or more; 10^{11} Wm^{-3}, or more; 10^{12} Wm^{-3}, or more; 10^{13} Wm^{-3}, or more, 10^{14} Wm^{-3}, or more; 10^{15} Wm^{-3}, or more.

17. A method of recycling articles which have parts made of different materials in them comprising pre-treating the articles in accordance with any one of claims 1 to 9 and then mechanically stressing the articles in order to break then up and facilitate the extraction of parts of the articles.

18. Apparatus for microwave treatment of material comprising:

a microwave treatment zone;

a microwave emitter disposed at said treatment zone;

a material transporter adapted to transport material through the treatment zone; the arrangement being such that:-

the emitter is adapted to emit microwaves that create a power density of at least $10^9 Wm^{-3}$, preferably 10^{15} or above;
and the material transporter is adapted to transport said material through the treatment zone fast enough so that said material experiences significant microwaves in said zone for a time of the order of ½ second or less, a time that is short enough to avoid causing substantial chemical change to the material.

19. Apparatus according to claim 18 adapted to cause said material to experience microwaves for a time of the order of (i) 0.1 second or less; or (ii) 0.01 second or less; or (iii) 0.001 second or less.

20. Apparatus according to claim 18 or claim 19 adapted to transport of the order of 1000 tonnes of material an hour through the treatment zone.

21. Apparatus according to any one of claims 18 to 20 wherein said emitter is adapted to produce microwave pulses with a duration of the order of a microsecond, or tens of microseconds, or hundreds of microseconds, or less, the material preferably receiving a plurality of pulses, and preferably many pulses, whilst it is in the treatment zone.

22. A method of continuous processing of ore or rocks comprising applying high power density microwaves, or high/electric field strength microwaves, on a continuous basis to ore or rocks passing through a microwave cavity or zone to weaken the ore or rocks at a speed that is fast enough to avoid causing substantial chemical change to the ore or rocks, and subsequently passing the continuous flow of ore or rocks to a mechanical treatment machine and mechanically breaking up the ore or rocks.

23. A method according to claim 22 wherein the exposure of the ore or rocks to the high field strength microwaves is of the order of half a second or less, or a quarter of a second or less, or 0.1 second or less, or 0.01 seconds or less.

24. Apparatus for continuous processing of ore or rocks comprising means for applying high power density microwaves, or high electric field strength microwaves, on a continuous basis to ore or rocks passing through a microwave cavity or zone to weaken the ore or rocks and feed means adapted to pass subsequently the continuous flow of ore or rocks to a mechanical treatment machine adapted mechanically to break up the ore or rocks.

25. A method of microwave pre-treatment of a multi-phase material prior to a subsequent operation on the material to extract one material from the others, the method comprising providing a continuous feed of the multi-phase material through a region in which applied microwave radiation is present, at a speed to allow a throughput of multi-phase material of at least 500 tonnes per hour, the microwave radiation creating a power density of at least 10^{15} Wm^{-3}, the material experiencing microwave radiation for a time of the order of 1ms or less, during which time it experiences one or a plurality of pulses of energy, preferably having a pulse duration of the order of microseconds or less, and wherein the overall bulk temperature of the multi-phase material does not rise by more than 40°C, and wherein thermal stress is created between phase boundaries which is large enough to cause inter phase fracturing, and wherein the temperature of the phases of the multi-phase material is kept low enough to avoid significant changes to the chemical properties of the different phase materials.

26. A method of increasing the yield of a mineral extracted from an ore having a plurality of phases of materials comprising causing weakening of inter-phase boundaries by exposing the ore to high field strength microwaves for a time of less than 0.1 or 0.01 second, the microwaves having a high enough field strength and being applied for a short enough time to cause differential thermal expansion between materials of different phases to cause weakening between phases whilst avoiding causing significant chemical changes to the ore, or at least to the mineral to be extracted.